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SPATIOTEMPORAL VARIATIONS IN THE DISTRIBUTION OF EELS (*ANGUILLA ANGUILLA*) IN A SMALL DAMMED CATCHMENT

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ABSTRACT - A sub-population of European eel (*Anguilla anguilla*) was sampled along the length of a small coastal catchments for seven consecutive years in late summer, the seasons when flows are low, to determine spatiotemporal variations of densities. Two hypothesis were explored: firstly, do habitat preferences vary among sizes; secondly, are spatial organisations patterns influenced by population parameters (density, size structure and sex ratio). Thus, years, length classes (≤ 150, [151-300], [301-450] and ≥ 451 mm), spatial distribution, and habitat characteristics were simultaneously explored using a GLM approach. Presence of dams determined greatly eel's spatial distribution. Small eels were observed in area where depth is low and aquatic vegetation abundant. Interannual densities was minimal for elvers and yellow eels even if high recruitment variability has been observed since 1996. This suggest that young recruits (i) delayed their upstream migration and/or, (ii) settled in deeper habitats and/or, (iii) had low survival during their migrating stages. Spatiotemporal patterns observed were then discussed regarding the development of the river and the saturation of the habitats suggesting that the carrying capacity was reached in the whole river system.

INTRODUCTION

European eel (*Anguilla anguilla*, L.) is an important commercial value throughout Europe (about Euro 180 million.year^{-1}). Considering the rarefaction of eels stock all over its distribution range since 1980's, ICES recently recommended that all means should be taken to restore the depleted stocks, at all biological stages (ICES, 1998).

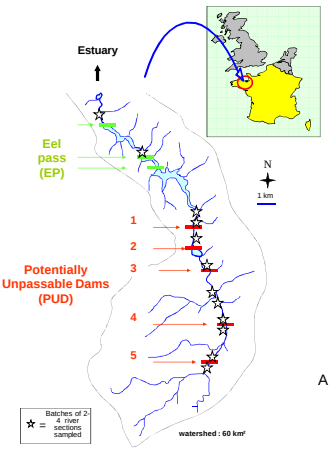
In this context, studies which consider spatiotemporal variations of abundance according to size/age are needed in order to model eel-habitat relationships.

The objective of the present study is to determine the **spatiotemporal variations** and **habitat effect in distribution** of eels density at the scale of the Frémur's catchment from 1995 to 2001.

We hypothesized that, since the abundance of Frémur's eel population seems to be very high compared to other west european catchments (Feunteun *et al.*, 2000), and eels are long-lived, its population should show little variability in time and space.

MATERIALS AND METHODS

Study site: Frémur's catchment



Sampling methods - Electrofishing

- 30-m long stream section
- 33 river sections sampled yearly
- Eel DENSITY (**DENS**, in nb.m^{-2}) assess (i) with standardized depletion method (Feunteun, 1994) and (ii) the model of Carle & Strub (1978).

Habitat measurement

- Aquatic Vegetation: cover index (0-5)
- Riparian Vegetation: cover index (0-5)
- *Substratum* Composition: Soft/Rocky
- Flow Velocity (m.s^{-1})
- Average **DEPTH**: 1: ≤ 30 cm; 2: 31-60 cm 3: 61-90 cm; 4: ≥ 91 cm

Analysis - 4 **LENGTH CLASSES** with different behaviors and ecology (Baisez, 2001)

1 : Elvers colonisation	≤ 150 mm
2 : Yellow eels	151-300 mm
3 : Highly sedentary male eels (Feunteun *et al.*, 2000)	301-450 mm
4: Highly sedentary female eels	≥ 451 mm

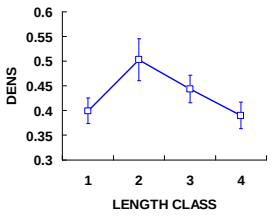
A GLM Stepwise procedure was performed to test spatiotemporal variations. **DENS** were normalized by reciproqual square root transformation (Box & Cox; Sakia, 1992). GLM residuals were homogeneous.

DENS = constant + LENGTH CLASS + DAMS CUM + HABITAT PARAMETERS + YEAR + interactions

with **DAMS CUM** =cumulated number of **PUD** from the estuary for habitat accessibility

RESULTS AND DISCUSSION

Predominance of LENGTH CLASSES 2, 3, expressed a fluvial recruitment, confirmed a sex ratio very skewed towards males (~ 70-80 %; Feunteun *et al.*, 2000).



General

- Total Number of eels = 6318 ind. during the whole sampling period
- Overall mean **DENS** = 0.49 ± 0.98 eels.m^{-2}

Model

- Model R-Square was 0.50.
- Riparian Vegetation, *Substratum* Composition and Flow Velocity not selected in the model.

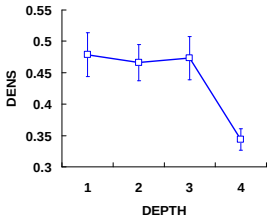
SOURCE OF VARIATIONS	Sum-of-Squares	DF	Mean-Square	F-ratio	Pr> F
LENGTH CL.	197.7	3	65.9	18.1	0.000
YEAR	50.6	6	8.4	2.3	< 0.05
DEPTH	508.6	3	169.5	46.6	0.000
DAMS CUM	333.6	5	66.7	18.3	0.000
AQUATIC VEGETATION	66.4	5	13.3	3.6	< 0.01
DEPTH × LENGTH CL.	163.6	9	18.2	5.0	0.000
DAMS CUM × LENGTH CL.	175.1	15	11.7	3.2	0.000
YEAR × LENGTH CL.	109.7	18	6.1	1.7	< 0.05

Length Cl + Year effects → **A**

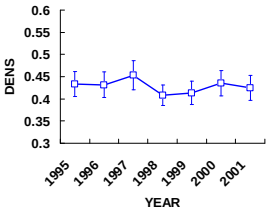
Habitat + Spatial effects → **B**

Length Class interactions → **C**

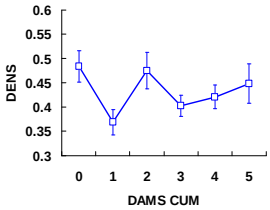
Suitable habitats presented low DEPTH and high AQUATIC VEGETATION cover



Significative but small annual variations of DENS knowing other effects



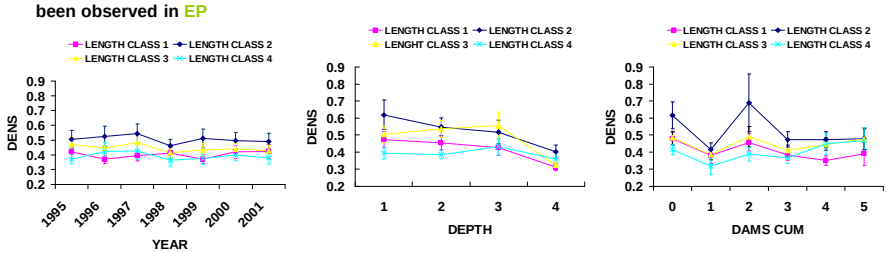
Concentration effect of eels beneath PUD 1 and 3.



Similar annual trends for the most abundant Length Cl. even though high recruitment variability has been observed in EP

Size class Depth *preferendum* observed for Length Classes 1 and 2

An optimal size (≤ 150 mm) and/or favourable hydraulic conditions to pass over dams



CONCLUSION

Our findings were partially in agreement with a recent theory (Feunteun *et al.*, 2003). They hypothesized that in saturated rivers where the carrying capacity is reached, a patchy 'fluid mosaic' organization may occur. Each patch corresponding to suitable habitats hosting a number of eels forming an assemblage with given characteristics (density, age and size structure) aging over years, independently from recruitment, until silvering and subsequent downstream migration occurs. In other world, eel population would show little variability in size distribution in time (*i.e.* interannual variations are low in stations where eels are abundant) and factors associated with their distribution would change with increasing size of fish.